Poster: Energy Consumption Impact of UHF RFID Reader Integration with Mobile Phones

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Introduction

UHF RFID has emerged as a mature technology with important applications in inventory control, pervasive computing and e-commerce but integration into mobile phone platforms has not yet been fully realized. One of the primary barriers contributing to this is a lack of understanding about how readers will impact the battery life of a mobile smartphone. In this work we describe our experimental investigation into the energy consumption impact of compact UHF Class-1 Generation-2 RFID readers as compared with existing sensors that are common in smartphones. Our evaluation shows that the energy consumption of compact RFID readers is affected by environmental conditions and network parameters that influence reader-tag link quality and that *reader energy consumption is comparable to existing integrated Bluetooth, GPS and WiFi interfaces on smartphones*. Existing experimental work on UHF readers (e.g., [1]) has focused mainly on tag read performance while our goal is to characterize how various factors impact the energy consumption of compact readers relative to existing smartphone sensors.

Methodology and Results

We examine the performance of three mobile EPC Class-1 Generation-2 RFID readers and three different types of tags. Readers we selected are: CAEN A528, CAEN R1230CB Quark and TagSense Nano; tags are: UPM Raflatac Short Dipole tags, CAEN A918 UHF passive tags and CAEN RT0005 Easy2Log Semi-Passive UHF temperature logger tags. For comparison, we obtained the energy profile from six integrated sensors on the HTC Magic Android smartphone. Custom apparatus was developed to allow the readers and smartphone to be powered by an Agilent E3631A power supply while in series with an Agilent 34410A digital multimeter. This apparatus was then used to capture high-resolution power measurements when the devices were performing different operations. Measurements so obtained were post-processed to determine the energy consumption and success of each operation in different scenarios.

We measured reader energy consumption as a function of several relevant variables, including reader type, tag type, reader-tag separation distance, reader transmit power, absence/presence of environmental obstacles, number of tags and the Q parameter.

Following is a list of some of the main observations from our results:

- Factors that have a significant impact on link quality (e.g., reader-tag separation) result in a correspondingly higher energy consumption due to the additional overhead for ensuring success of a given operation (e.g., read).
- Reader-tag separation distance degrades link quality in a predictable way as a tag moves out of a reader's range and communication success rate drops quickly.
- Energy consumption of a reader depends on the nature of the operation it carries out – write operations are the most expensive so much so that a single write operation consumes more energy than inventory and read operations put together.
- We also observe that setting the *Q* parameter of a reader without consideration to number of tags in its range causes higher energy consumption due to the longer *Query Cycle*.

Our evaluation of the energy costs for RFID readers compared to the existing sensors integrated into a smartphone show that readers can be grouped into the same energy consumption class as WiFi, GPS and Bluetooth interfaces. The power consumption of readers was higher in general than the smartphone sensors but the operations performed by readers are much shorter in duration (between .03 and .3 seconds depending on reader) than the smartphone sensors' tasks. Fig. 1 shows the number of operations of inventory followed by a read that a reader can perform given the energy consumed by a phone sensor (e.g., WiFi) to carry out a typical operation (e.g., AP scan).

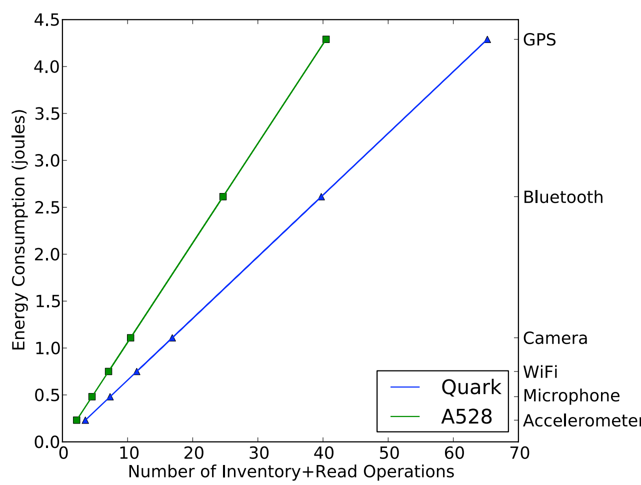

Figure 1. The number of inventory+read operations for the Quark and A528 readers with a temperature logger tag relative to the energy consumed by each of the phone sensors to do a typical operation. For example, taking a picture using the phone camera consumes little over a joule. Other experiment settings are: 1m tag-reader separation distance, 200mW reader transmit power, optimal tag-antenna orientation and unobstructed line of sight.

Given our finding that compact UHF readers have similar energy consumption as sensors that are already integrated into current smartphones, we can conclude that it is feasible from a battery life perspective to integrate UHF readers into smartphones to expand their sensing capabilities. Further use of reader duty cycling schemes would only strengthen the argument in favor of their integration into modern mobile phones.

References

1. M. Buettner and D. Wetherall. An Empirical Study of UHF RFID Performance. In *Proc. ACM MobiCom* (2008).